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NATIONAL EUTROPHICATION SURVEY

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REPORT

ON

DEERFIELD LAKE

PENNINGTON COUNTY

SOUTH DAKOTA

EPA REGION VIII

WORKING PAPER No. 607

WITH THE COOPERATION OF THE

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENTAL PROTECTION

AND THE

SOUTH DAKOTA NATIONAL GUARD

JANUARY, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the South Dakota Departments of Environmental Protection and Game, Fish and Parks for professional involvement, to the South Dakota National Guard for conducting the tributary sampling phase of the Survey, and to those wastewater treatment plant operators who voluntarily provided effluent samples.

Allyn Lockner, Secretary, and Blaine Barker and Duane Murphy, Department of Environmental Quality; Douglas Hansen, Department of Game, Fish and Parks; and James Hayden, Director, State Lakes Preservation Committee provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

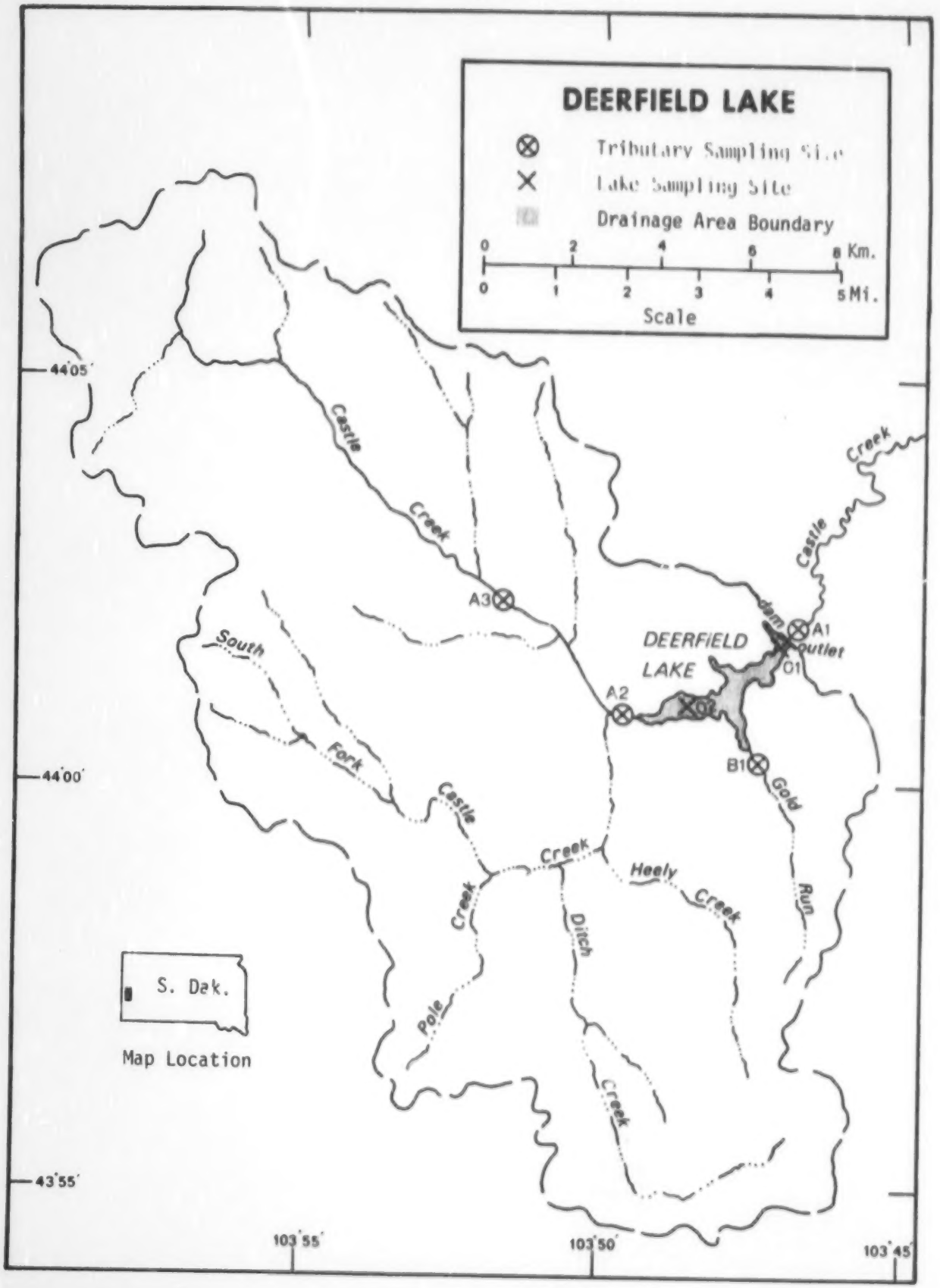
Major General Duane L. Corning, the Adjutant General of South Dakota, and Project Officer Colonel Robert D. Chalberg, who directed the volunteer efforts of the South Dakota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF SOUTH DAKOTA

LAKE NAME	COUNTY
Albert	Kingsbury
Alvin	Lincoln
Angostura	Fall River
Brant	Lake
Byron	Beadle
Clear	Marshall
Clear	Minnehaha
Cochrane	Deuel
Cottonwood	Spink
Deerfield	Pennington
Enemy Swim	Day
Herman	Lake
John	Hamlin
Kampeska	Codington
Madison	Lake
Mitchell	Davidson
Norden	Hamlin
East Oakwood	Brookings
West Oakwood	Brookings
Pactola	Pennington
Pickerel	Day
Poinsett	Brookings, Lake
Red Iron South	Marshall
Richmond	Brown
Roy	Marshall
Sand	Brown
Sheridan	Pennington
Stockdale	Custer
East Vermillion	McCook
Wall	Minnehaha
Waubay	Day


DEERFIELD LAKE
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
0 2 4 6 8 Km.
0 1 2 3 4 5 Mi.
Scale
44°05'
44°00'
43°55'
103°55'
103°50'
103°45'
Castle Creek
Castle Creek
South Fork
Castle Creek
Pole Creek
Ditch Creek
Heely Creek
Gold Run
DEERFIELD LAKE
dam
outlet
A1
A2
A3
B1
O1
O2
S. Dak.
Map Location

DEERFIELD LAKE

STORET NO. 4610

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Deerfield Lake is mesotrophic, although it ranked sixth in overall trophic quality when the 31 South Dakota lakes sampled in 1974 were compared using a combination of six water quality parameters*. However, this lake was sampled at much greater depths than four of the five lakes that ranked higher, and depletion of dissolved oxygen occurred at a depth of nearly 26 meters in April. If dissolved oxygen is omitted as an index parameter, Deerfield Lake would rank third.

Three of the 31 lakes had less median total phosphorus, 13 had less median dissolved orthophosphorus, three had less and one had the same median inorganic nitrogen, and only oligotrophic Pactola Reservoir had less mean chlorophyll a and a greater mean Secchi disc transparency.

Survey limnologists noted some emergent macrophytes along the shoreline near sampling station 2 in July.

B. Rate-Limiting Nutrient:

Because of nutrient changes in the sample, the algal assay results are not considered representative of conditions in the

* See Appendix A.

lake at the time the sample was taken (09/11/74). However, the lake data indicate phosphorus limitation in April and nitrogen limitation in July and September.

C. Nutrient Controllability:

1. Point sources--There were no known point sources discharging to Deerfield Lake or its tributaries during the sampling year.

The present phosphorus loading of 0.19 g/m^2/year is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading (see page 10). However, the mean phosphorus concentration in ungaged Gold Run was over twice that of Castle Creek, and the loading may be somewhat higher than indicated.

2. Non-point sources--Non-point sources contributed all of the total phosphorus load to Deerfield Lake during the sampling year. Castle Creek contributed 81.2%, and the ungaged minor tributaries and immediate drainage contributed an estimated 9.4%.

The area surrounding the lake is forest and grazing land. Moderately high phosphorus concentrations found in the lake may be due in part to direct runoff from such areas. An investigation of land-use practices would be necessary to determine the contribution from such sources.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 1.68 kilometers^2.
2. Mean depth: 10.5 meters.
3. Maximum depth: 33.5 meters.
4. Volume: 17.709 x 10^6 m^3.
5. Mean hydraulic retention time: 2 years.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Castle Creek	215.0	0.270
Minor tributaries & immediate drainage -	31.9	0.007
Totals	246.9	0.277

2. Outlet -

Castle Creek	248.6**	0.277**

C. Precipitation***:

1. Year of sampling: 67.1 centimeters.
2. Mean annual: 70.4 centimeters.

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† Table of metric conversions--Appendix B.
†† Surface area - Murphey, 1974; volume - Anonymous, 1976.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Deerfield Lake was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the September visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 25.9 meters at station 1 and 6.4 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR DEERFIELD RESERVOIR
STORET CODE 4610

PARAMETER	1ST SAMPLING (4/25/74) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/15/74) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/11/74) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	3.3 - 5.9	4.9	5.4	8.3 - 20.7	16.8	19.9	8.7 - 15.4	13.4	15.2
DISS OXY (MG/L)	0.0 - 10.4	7.3	8.2	2.0 - 10.2	6.9	7.5	0.1 - 8.0	4.8	7.4
CNDCTVY (MCROMO)	224. - 286.	243.	245.	291. - 356.	336.	352.	271. - 287.	281.	283.
PH (STAND UNITS)	****** -**********			7.8 - 8.5	8.3	8.4	7.4 - 8.4	8.0	8.2
TOT ALK (MG/L)	188. - 236.	205.	202.	218. - 242.	229.	228.	198. - 236.	211.	200.
TOT P (MG/L)	0.010 - 0.270	0.048	0.021	0.041 - 0.089	0.062	0.062	0.313 - 0.073	0.036	0.028
ORTHO P (MG/L)	0.004 - 0.022	0.007	0.005	0.042 - 0.081	0.051	0.045	0.005 - 0.048	0.021	0.019
NO2+NO3 (MG/L)	0.030 - 0.100	0.049	0.050	0.030 - 0.070	0.057	0.060	0.020 - 0.020	0.020	0.020
AMMONIA (MG/L)	0.020 - 1.180	0.158	0.030	0.020 - 0.050	0.039	0.040	0.020 - 0.190	0.057	0.035
KJEL N (MG/L)	0.200 - 1.500	0.400	0.200	0.200 - 0.300	0.220	0.200	0.200 - 0.400	0.242	0.200
INORG N (MG/L)	0.050 - 1.210	0.207	0.080	0.050 - 0.120	0.096	0.100	0.040 - 0.210	0.077	0.055
TOTAL N (MG/L)	0.230 - 1.530	0.449	0.300	0.250 - 0.360	0.277	0.260	0.220 - 0.420	0.262	0.220
CHLRPYL A (UG/L)	3.9 - 4.6	4.2	4.2	2.8 - 6.3	4.5	4.5	2.1 - 2.2	2.1	2.1
SECCHI (METERS)	3.0 - 5.5	4.3	4.3	5.0 - 7.3	6.1	6.1	4.6 - 4.6	4.6	4.6

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/25/74	1. Chroomonas sp.	2,142
	2. Syndra sp.	863
	3. Cryptomonas sp.	480
	4. Asterionella sp.	288
	5. Tabellaria sp.	64
	Total	3,837
07/15/74	1. Chroomonas sp.	521
	2. Fragilaria sp.	290
	3. Cryptomonas sp.	203
	4. Flagellates	87
	5. Centric diatoms	116
	Other genera	115
	Total	1,332
09/11/74	1. Chroomonas sp.	265
	2. Asterionella sp.	151
	3. Fragilaria sp.	114
	4. Anabaena sp.	38
	5. Cryptomonas sp.	38
	Other genera	113
	Total	719

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/25/74	1	4.6
	2	3.9
07/15/74	1	6.3
	2	2.8
09/11/74	1	2.2
	2	2.1

C. Limiting Nutrient Study:

The algal assay results are not considered representative of conditions in the lake at the time the sample was taken 09/11/74) due to nutrient changes in the sample during shipment from the field to the laboratory.

The lake data indicate phosphorus was limiting in April (the mean inorganic nitrogen/orthophosphorus ratios were 33/1 at station 1 and 16/1 at station 2). However, nitrogen limitation is indicated in July and September (the mean N/P ratios were 5/1 or less at both stations, and nitrogen limitation would be expected).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the South Dakota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of April and June when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the South Dakota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station A-2, in kg/km^2/year, and multiplying by the ZZ area in km^2.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

* See Working Paper No. 175.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Castle Creek	260	81.2
b. Minor tributaries & immediate drainage (non-point load) -	30	9.4
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	30	9.4
Total	320	100.0

2. Outputs -

Lake outlet - Castle Creek 275

3. Net annual P accumulation - 45 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Castle Creek	5,175	66.7
b. Minor tributaries & immediate drainage (non-point load) -	765	9.9
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	1,815	23.4
Total	7,755	100.0

2. Outputs -

Lake outlet - Castle Creek 5,500

3. Net annual N accumulation - 2,255 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Castle Creek	1	24

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Gold Run	0.064	0.903

* See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.19	0.03	4.6	1.3

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Deerfield Lake:	
"Dangerous" (eutrophic loading)	0.46
"Permissible" (oligotrophic loading)	0.23

V. LITERATURE REVIEWED

Anonymous, 1976. Water resources data for South Dakota, water year 1975. Water Data Report SD-75-1, U.S.G.S., Huron.

Murphey, Duane G., 1974. Personal communication (water body information and morphometry). SD Dept. of Env. Prot., Pierre.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
4601	LAKE ALBERT	0.321	0.170	489.111	106.289	9.200	0.019
4602	ALVIN LAKE	0.067	0.970	442.833	4.700	9.400	0.017
4603	ANGOSTURA RESERVOIR	0.019	0.160	423.333	3.717	13.000	0.005
4604	BRANT LAKE	0.194	0.130	432.833	34.150	11.800	0.113
4605	LAKE BYRON	0.443	0.370	488.333	149.350	9.000	0.146
4606	CLEAR LAKE	0.027	0.075	430.167	11.983	8.800	0.009
4607	CLEAR LAKE	1.400	0.270	495.333	691.000	7.000	0.468
4608	COCHRANE LAKE	0.037	0.150	446.000	15.683	15.000	0.008
4609	COTTONWOOD LAKE	0.685	0.265	490.333	112.017	8.600	0.417
4610	DEERFIELD RESERVOIR	0.033	0.080	303.333	3.650	15.000	0.022
4611	ENEMY SWIM LAKE	0.037	0.085	442.600	14.200	8.200	0.013
4612	LAKE HERMAN	0.340	0.155	485.000	58.733	8.600	0.174
4613	ST JOHN LAKE	0.348	0.080	489.400	120.880	9.800	0.025
4614	LAKE KAMPESKA	0.220	0.105	468.889	20.567	8.200	0.128
4615	MADISON LAKE	0.250	0.090	445.555	22.578	14.000	0.107
4616	LAKE MITCHELL	0.099	0.085	465.833	14.883	13.800	0.015
4617	LAKE NORDEN	0.256	0.165	488.667	46.800	10.000	0.050
4618	OAKWOOD LAKE EAST	0.146	0.175	487.000	113.600	10.000	0.009
4619	OAKWOOD LAKE WEST	0.181	0.135	485.833	159.667	9.600	0.021
4620	PACTOLA RESERVOIR	0.011	0.070	248.444	1.478	11.000	0.006
4621	PICKEREL LAKE	0.049	0.095	439.833	15.833	9.600	0.009
4622	LAKE POINSETT	0.115	0.315	468.444	40.211	10.000	0.023
4623	LAKE RED IRON SOUTH	0.042	0.110	430.333	6.883	7.600	0.010
4624	RICHMOND LAKE	0.187	0.150	410.000	18.467	10.000	0.144
4625	ROY LAKE	0.034	0.070	431.000	13.333	11.000	0.010
4626	SAND LAKE	0.489	0.110	471.800	65.790	12.800	0.288
4627	SHERIDAN LAKE	0.053	0.105	394.000	15.433	15.000	0.016
4628	STOCKADE LAKE	0.233	0.150	432.000	25.400	15.000	0.109

AKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
4629	LAKE VERMILLION	0.211	0.100	472.833	100.800	9.200	0.092
4630	WALL LAKE	0.194	0.169	441.667	55.267	7.400	0.076
4631	WAUBAY LAKE NORTH	0.098	0.145	469.555	127.033	11.400	0.023

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
4601	LAKE ALBERT	20 (6)	20 (6)	10 (3)	23 (7)	68 (20)	60 (18)	201
4602	ALVIN LAKE	67 (20)	0 (0)	57 (17)	90 (27)	63 (19)	63 (19)	340
4603	ANGOSTURA RESERVOIR	97 (29)	30 (9)	87 (26)	93 (28)	20 (6)	100 (30)	427
4604	BRANT LAKE	40 (12)	53 (16)	70 (21)	47 (14)	27 (8)	23 (7)	260
4605	LAKE BYRON	10 (3)	3 (1)	17 (5)	7 (2)	73 (22)	13 (4)	123
4606	CLEAR LAKE	93 (28)	93 (28)	83 (25)	83 (25)	77 (23)	90 (27)	519
4607	CLEAR LAKE	0 (0)	10 (3)	0 (0)	0 (0)	100 (30)	0 (0)	110
4608	COCHRANE LAKE	83 (25)	40 (11)	50 (15)	67 (20)	5 (0)	93 (28)	338
4609	COTTONWOOD LAKE	3 (1)	13 (4)	3 (1)	20 (6)	82 (24)	3 (1)	124
4610	DEERFIELD RESERVOIR	90 (27)	88 (26)	97 (29)	97 (29)	5 (0)	53 (16)	430
4611	ENEMY SWIM LAKE	80 (24)	82 (24)	60 (18)	77 (23)	88 (26)	73 (22)	460
4612	LAKE HERMAN	17 (5)	33 (10)	27 (8)	33 (10)	82 (24)	10 (3)	202
4613	ST JOHN LAKE	13 (4)	88 (26)	7 (2)	13 (4)	53 (16)	43 (13)	217
4614	LAKE KAMPESKA	33 (10)	65 (19)	40 (12)	57 (17)	88 (26)	20 (6)	303
4615	MADISON LAKE	27 (8)	77 (23)	53 (16)	53 (16)	13 (4)	30 (9)	253
4616	LAKE MITCHELL	60 (18)	82 (24)	47 (14)	73 (22)	17 (5)	70 (21)	349
4617	LAKE NORDEN	23 (7)	23 (7)	13 (4)	40 (12)	45 (12)	40 (12)	184
4618	OAKWOOD LAKE EAST	53 (16)	17 (5)	20 (6)	17 (5)	45 (12)	85 (25)	237
4619	OAKWOOD LAKE WEST	50 (15)	50 (15)	23 (7)	3 (1)	58 (17)	57 (17)	241
4620	PACTOLA RESERVOIR	100 (30)	98 (29)	100 (30)	100 (30)	35 (10)	97 (29)	530
4621	PICKEREL LAKE	73 (22)	73 (22)	67 (20)	63 (19)	58 (17)	85 (25)	419
4622	LAKE POINSETT	57 (17)	7 (2)	43 (13)	43 (13)	45 (12)	47 (14)	242
4623	LAKE RED IRON SOUTH	77 (23)	58 (17)	80 (24)	87 (26)	93 (28)	78 (23)	473
4624	RICHMOND LAKE	47 (14)	40 (11)	90 (27)	60 (18)	45 (12)	17 (5)	299
4625	ROY LAKE	87 (26)	98 (29)	77 (23)	80 (24)	35 (10)	78 (23)	455
4626	SAND LAKE	7 (2)	58 (17)	33 (10)	30 (9)	23 (7)	7 (2)	158
4627	SHERIDAN LAKE	70 (21)	65 (19)	93 (28)	70 (21)	5 (0)	67 (20)	370
4628	STOCKADE LAKE	30 (9)	40 (11)	73 (22)	50 (15)	5 (0)	27 (8)	225

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P	INDEX NO
4629	LAKE VERMILLION	37 (11)	70 (21)	30 (9)	27 (8)	68 (20)	33 (10)	265
4630	WALL LAKE	43 (13)	27 (8)	63 (19)	37 (11)	97 (29)	37 (11)	304
4631	WAUBAY LAKE NORTH	63 (19)	47 (14)	37 (11)	10 (3)	30 (9)	50 (15)	237

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	4620	PACTOLA RESERVOIR	530
2	4606	CLEAR LAKE	519
3	4623	LAKE RED IRON SOUTH	473
4	4611	ENEMY SWIM LAKE	460
5	4625	ROY LAKE	455
6	4610	DEERFIELD RESERVOIR	430
7	4603	ANGOSTURA RESERVOIR	427
8	4621	PICKEREL LAKE	419
9	4627	SHERIDAN LAKE	370
10	4616	LAKE MITCHELL	349
11	4602	ALVIN LAKE	340
12	4608	COCHRANE LAKE	338
13	4630	WALL LAKE	304
14	4614	LAKE KAMPESKA	303
15	4624	RICHMOND LAKE	299
16	4629	LAKE VERMILLION	265
17	4604	BRANT LAKE	260
18	4615	MADISON LAKE	253
19	4622	LAKE POINSETT	242
20	4619	OAKWOOD LAKE WEST	241
21	4631	WAUBAY LAKE NORTH	237
22	4618	OAKWOOD LAKE EAST	237
23	4628	STOCKADE LAKE	225
24	4613	ST JOHN LAKE	217
25	4612	LAKE HERMAN	202
26	4601	LAKE ALBERT	201
27	4617	LAKE NORDEN	184
	4626	SAND LAKE.	158

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
29	4609	COTTONWOOD LAKE	124
30	4605	LAKE BYRON	123
31	4607	CLEAR LAKE	110

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR SOUTH DAKOTA 05/03/76

LAKE CODE 4610 DEERFIELD RES

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 248.6

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
4610A1	248.6	0.057	0.057	0.113	0.311	0.453	0.453	0.453	0.510	0.538	0.255	0.085	0.057	0.280
4610A2	215.0	0.20	0.20	0.23	0.40	0.42	0.37	0.28	0.25	0.23	0.23	0.23	0.20	0.27
4610ZZ	33.7	0.0	0.0	0.0	0.028	0.028	0.028	0.0	0.0	0.0	0.0	0.0	0.0	0.007

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 248.6
SUM OF SUB-DRAINAGE AREAS = 248.6

TOTAL FLOW IN = 3.31
TOTAL FLOW OUT = 3.34

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4610A1	10	74	0.311	12	0.340				
	11	74	0.085	9	0.057				
	12	74	0.057	7	0.057				
	1	75	0.085	9	0.085	18	0.085		
	2	75	0.085	9	0.085				
	3	75	0.142	8	0.085				
	4	75	0.708	12	0.311	30	1.218		
	5	75	0.793	16	0.793				
	6	75	0.425	4	0.368	14	0.340		
	7	75	0.340	12	0.311				
	8	75	0.255	28	0.255				
	9	75	0.425	21	0.481				
4610A2	10	74	0.255	12	0.255				
	11	74	0.311	9	0.311				
	12	74	0.311	7	0.340				
	1	75	0.255	9	0.283	18	0.227		
	2	75	0.227	9	0.227				
	3	75	0.227	8	0.227				
	4	75	0.708	12	0.340	30	0.566		
	5	75	0.481	16	0.566				
	6	75	0.340	4	0.425	14	0.340		
	7	75	0.227	12	0.227				
	8	75	0.255	28	0.227				
	9	75	0.283	21	0.255				
4610ZZ	10	74	0.0						
	11	74	0.0						
	12	74	0.0						
	1	75	0.0						
	2	75	0.0						
	3	75	0.0						
	4	75	0.008						
	5	75	0.028						
	6	75	0.028						
	7	75	0.014						
	8	75	0.0						
	9	75	0.0						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/05/03

461001
44 01 42.0 103 47 10.0 3
DEERFIELD RESERVOIR
46103 SOUTH DAKOTA

090491

11EPALES 2111202
0090 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/25	10 20	0000	5.9		216	224		188	0.020	0.200	0.030	0.005
	10 20	0005	5.9	10.4		224		191	0.040	0.200	0.060	0.006
	10 20	0020	5.8	10.0		226		191	0.020	0.200	0.030	0.005
	10 20	0045	3.6	8.0		245		204	0.020	0.200K	0.050	0.004
	10 20	0060	3.3	6.0		248		214	0.050	0.200	0.100	0.007
	10 20	0085	4.0	0.0		286		236	1.180	1.500	0.030	0.022
74/07/15	13 40	0000	20.1	7.4	288	352	8.50	218	0.040	0.300	0.060	0.045
	13 40	0005	20.1	7.2		352	8.50	226	0.040	0.200	0.070	0.046
	13 40	0020	20.1	7.6		350	8.50	222	0.040	0.200	0.060	0.044
	13 40	0035	10.9	6.8		304	8.10	240	0.020	0.300	0.030	0.043
	13 40	0055	8.8	3.8		295	7.90	242	0.050	0.200K	0.070	0.042
	13 40	0070	8.3	2.0		291	7.80	230	0.050	0.200K	0.060	0.044
74/09/11	15 45	0000	15.4	8.0	180	285	8.31	198	0.030	0.200K	0.020K	0.005
	15 45	0005	15.4	8.0		283	8.25	198	0.020	0.200K	0.020K	0.014
	15 45	0020	15.3	7.4		283	8.23	199	0.020K	0.200	0.020K	0.012
	15 45	0040	14.0	2.6		287	7.73	220	0.020K	0.200K	0.020K	0.013
	15 45	0045	11.8	0.2		285	7.41	228	0.030	0.200K	0.020K	0.018
	15 45	0050	9.8	0.2		273	7.43	232	0.050	0.200K	0.020K	0.024
	15 45	0060	9.0	0.1		271	7.47	236	0.160	0.300	0.020K	0.023
	15 45	0081	8.7	0.2		273	7.49	222	0.190	0.400	0.020K	0.025

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/03

461001
44 01 42.0 103 47 10.0 3
DEERFIELD RESERVOIR
46103 SOUTH DAKOTA
090491

11EPALES 2111202
0090 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/25	10	20 0000	0.019	4.6	
	10	20 0005	0.028		
	10	20 0020	0.022		
	10	20 0045	0.010		1.0
	10	20 0060	0.020		
	10	20 0085	0.270		
74/07/15	13	40 0000	0.065	6.3	
	13	40 0002			50.0
	13	40 0005	0.041		
	13	40 0020	0.057		
	13	40 0035	0.068		1.0
	13	40 0055	0.049		
	13	40 0070	0.056		
74/09/11	15	45 0000	0.013	2.2	
	15	45 0005	0.023		
	15	45 0020	0.023		
	15	45 0040	0.022		
	15	45 0045	0.026		
	15	45 0050	0.033		
	15	45 0060	0.066		
	15	45 0081	0.073		

STORET RETRIEVAL DATE 76/05/03

461002
44 00 52.0 103 48 35.0 3
DEERFIELD RESERVOIR
46103 SOUTH DAKOTA

090491

11EPALES 2111202
0025 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/25	11	00 0000	5.8		120	246		202	0.040	0.400	0.050	0.005
	11	00 0005	5.4	8.2		244		202	0.020	0.300	0.040	0.004
	11	00 0020	4.2	8.8		246		214	0.030	0.400	0.050	0.005
74/07/15	14	05 0000	20.6	7.8	196	356	8.40	222	0.040	0.200	0.060	0.048
	14	05 0005	20.7	8.0		355	8.40	224	0.040	0.200K	0.050	0.062
	14	05 0010	19.7	8.4		352	8.40	230	0.040	0.200K	0.060	0.052
	14	05 0020	18.5	10.2		354	8.30	234	0.030	0.200	0.050	0.081
74/09/11	15	15 0000	15.2	8.0	180	281	8.27	199	0.040	0.400	0.020K	0.015
	15	15 0005	15.2	8.0		285	8.37	200	0.020	0.200K	0.020K	0.021
	15	15 0015	15.2	8.0		287	8.37	200	0.050	0.200K	0.020K	0.031
	15	15 0021	15.2	7.4		283	8.37	200	0.060	0.200K	0.020K	0.048

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/25	11	00 0000	0.024	3.9	
	11	00 0005	0.021		
	11	00 0020	0.020		
74/07/15	14	05 0000	0.072	2.8	
	14	05 0005	0.065		
	14	05 0010	0.059		
	14	05 0020	0.089		1.0
74/09/11	15	15 0000	0.023	2.1	
	15	15 0005	0.030		
	15	15 0015	0.035		
	15	15 0021	0.064		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/05/04

461041
44 01 45.0 103 46 53.0 4
CASTLE CREEK
46 7.5 DEERFIELD
D/DEERFIELD LAKE 090491
BNDG .2 M DNSTRM FRM DEERFIELD DAM
11EPALES 211120
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS MG/L P	00665 PHOS-TOT MG/L P
74/10/12	11 40		0.024	0.600	0.010	0.010K	0.030
74/11/09	12 10		0.040	0.600	0.025	0.015	0.020
74/12/07	08 50		0.040	0.400	0.010	0.010	0.020
75/03/08	09 30		0.216	0.950	0.032	0.008K	0.010
75/04/12			0.050	0.350	0.035	0.010	0.020
75/04/30	20 45		0.150	0.900	0.030	0.015	0.030
75/05/16	15 15		0.100	0.100	0.060	0.005	0.020
75/06/04	13 15		0.040	0.750	0.020	0.005	0.030
75/06/16	10 45		0.025	0.250	0.005	0.005K	0.030
75/07/12	13 40		0.005	0.600	0.020	0.010	0.010
75/08/28	18 23		0.035	0.500	0.060	0.025	0.070
75/09/21			0.035	0.600	0.115	0.015	0.110

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

4610A2
44 00 49.0 103 49 48.0 4
CASTLE CREEK
46 7.5 DEERFIELD
T/DEERFIELD LAKE 040491
SEC RD BRDG 2.5 MI S= OF DEERFIELD DAM
11EPALES 211204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/12	12 50		0.040	0.500	0.005	0.015	0.040
74/11/09	13 00		0.104	0.100	0.015	0.015	0.020
74/12/07	09 45		0.168	0.200	0.005	0.010	0.010
75/02/09	13 00		0.184	0.600	0.032	0.016	0.030
75/03/08	10 00		0.172	0.600	0.024	0.008	0.020
75/04/12			0.165	1.300	0.040	0.020	0.050
75/04/30	14 20		0.165	0.650	0.015	0.025	0.060
75/05/16	15 27		0.070	0.400	0.015	0.015	0.030
75/06/04	13 45		0.065	0.600	0.025	0.010	0.040
75/06/14	11 30		0.070	0.600	0.010	0.005	0.050
75/07/12	13 55		0.015	0.400	0.015	0.010	0.020
75/08/28	18 35		0.010	0.550	0.020	0.005	0.015
75/09/21			0.065	0.200	0.010	0.005K	0.010

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

461043
44 02 21.0 103 51 42.0 4
CASTLE CREEK
46 7.5 DEERFIELD
T/DEERFIELD LAKE 090491
BRDG HALFWAY BTWN MILLER/PRICKETT RANCHS
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/12	12 25		0.064	0.400	0.015	0.005K	0.010
74/11/09	12 49		0.104	0.200	0.025	0.010	0.030
74/12/07	09 30		0.168	0.300	0.010	0.005	0.020
75/01/09	13 10		0.176	0.400	0.016	0.010	0.020
75/02/08	09 00		0.168	0.100	0.016	0.008	0.050
75/03/08	10 10		0.176	0.300	0.016	0.008	0.010
75/04/12			0.175	0.750	0.020	0.015	0.040
75/04/30	19 30		0.270	0.550	0.035	0.035	0.060
75/05/16	15 30		0.180	0.400	0.025	0.010	0.010
75/06/04	13 50		0.155	0.550	0.015	0.005	0.030
75/06/14	11 15		0.170	0.650	0.025	0.005K	0.060
75/07/12	14 00		0.070	0.250	0.020	0.010	0.010
75/08/28	18 45		0.045	0.350	0.020	0.010	0.020
75/09/21			0.100	0.300		0.005K	0.010

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

461051
44 00 20.0 103 47 35.0 4
GOLD RUN
46 7.5 DEERFIELD
T/DEERFIELD LAKE , 0+0491
SEC RD BRDG 1.7 MI S OF DEERFIELD DAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/09	13	25	0.016	0.500	0.040	0.040	0.085
75/04/30	19	05	0.125	0.800	0.020	0.035	0.060
75/05/16	15	27	0.010	0.675	0.015	0.020	0.030
75/06/04	13	30	0.025	0.950	0.030	0.025	0.080
75/06/14	11	45	0.015	0.825	0.025	0.020	0.031
75/07/12	15	50	0.005	0.550	0.025	0.050	0.070
75/08/28	18	27	0.020	1.450	0.045	0.065	
75/09/21			0.055	1.200	0.020	0.025	0.090